



QUALITY DISTRIBUTION OF PALLET PARTS FROM LOW-GRADE LUMBER

by

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ABSTRACT

To produce better pallets, the higher quality parts should be used in the more vulnerable positions in the pallet. To determine the feasibility of doing this, pallet parts cut from commonly used lumber mixes were graded into four quality levels. The distributions obtained indicate that sufficient numbers of high-quality parts can be cut from existing raw material to allow selective placement. Four species groups—eastern hardwood, southern pine, Douglas-fir, and a small amount of western hardwood—were included in the study.

The most efficient way to produce better pallets is to place higher quality parts in critical places in the pallet. The “PEP” study on the performance of wooden pallets under normal use conditions has shown that the more exposed pallet parts are subject to more damage than interior parts.¹ The selective placement of high-quality parts in the pallet structure reduces damage and extends the useful life of a pallet. To employ our wood resources efficiently and to minimize the cost of the wooden pallet, pallets must be constructed so as to get the maximum benefit from the raw materials available.

The primary objective of this study was to determine if the mix of lumber presently used to manufacture pallet parts is high enough in quality to provide the quality parts needed in the exposed locations of pallets.

The vulnerable areas of the pallet referred to here include:

- (a) the two top deck endboards—15 percent of the total deck volume;
- (b) the two bottom deck endboards—15 percent of the total deck volume; and
- (c) the two outside stringers—67 percent of the total stringer volume.

A secondary objective was to evaluate the effect of species and cutting method on the quality distribution of parts cut from commonly used lumber grades.

BACKGROUND

Before World War II there was a very limited market for the low-grade lumber cut in and around the pith area of logs, and this waste material created disposal problems in many sawmills. The handling of unit loads of products with forklift trucks and wooden pal-

¹Wallin, W. B., J. J. Strobel, R. E. Frost, and P. R. Stinson, PEP Research Study Report. Unpublished. Northeastern Forest Experiment Station, Forest Products Marketing Laboratory, Princeton, West Virginia 482 pp.

lets developed during World War II. The adoption of this method by industry has provided large and stable market outlets for the low-grade lumber used to manufacture wooden pallets. The wooden pallet and container industry now uses nearly one-fourth of all hardwood lumber produced in the United States. Increased handling costs have encouraged unit-load movement of goods and in turn increased the demand for pallets.

During the years immediately following World War II, the pallet and container industry was almost perfectly competitive. There were many small firms producing and selling pallets; entry into and exit from the industry was easy because the investment in plant and equipment was very low; and the products of different manufacturers were not differentiated. In an attempt to relieve some of the competitive pressure, many manufacturers took advantage of small "captive" markets whereby they could differentiate their products by producing a pallet for a specific industry need. Pallets were used primarily for handling products in plants, and as a result pallet sizes and designs were specified to fit individual products. Exchange of pallets between different owners did not develop significantly until the middle 1950s.

Pallet Exchange System

The most efficient application of unit-load handling is the system in which pallets are exchanged freely among the various shippers, carriers, and receivers in different establishments, firms, and industries. Such a system on a national scale reduces the costs of handling and shipping products by using labor and equipment more efficiently, by using pallets more efficiently, and by using raw materials more efficiently to produce pallets. But because different firms and industries use such a wide range of pallet designs and sizes, the implementation of major inter-industry pallet exchange systems is hampered.

Two basic requirements of pallets to be used in exchange systems are: (1) standards of quality for all pallets within the system to insure equal exchange; and (2) standards of design and size to insure that all pallets can be used in all materials handling systems and in all transportation equipment.

Current Practices

Pallet manufacturers use lumber that is "left over" from the manufacture of other primary products. The cost, quality, and species mix of lumber available for pallet manufacture varies with and is dependent upon the markets for such primary products as furniture, general construction, flooring, and cross-ties. Most pallets are manufactured from what is known as "pallet grade" or "sound square edge" lumber and cants. In standard lumber grade terms, pallet grade material is generally composed of varying proportions of No. 3A and 3B Common, and in some instances a small portion of No. 2 Common, lumber. Most pallet producers do not grade the lumber they buy; nor do they grade the pallet parts they produce. Different quality pallets are normally produced by varying the proportions of higher quality lumber used to produce the parts and by setting higher quality levels for "culling out" unsuitable parts after manufacture.

Before there can be a quality selection system for pallet parts that will insure the placement of high-quality parts in vulnerable areas of a pallet, quality classes must be defined and their distributions measured. After quality distributions have been determined, the information can then be related to the quality selection system.

This information is of value to pallet producers as a means of evaluating the quality of parts they presently produce or buy, and to pallet users as a means of determining that the pallets actually do meet the specifications.

METHODS

Four species groups—eastern hardwood, southern pine, Douglas-fir, and western hardwood—all commonly used in the production of pallets, were included in the survey. Pallet deckboards were selected at random from existing inventories at several pallet plants in the eastern, southern, and western United States. Only deckboards were evaluated in this survey because they were available and easily graded. It was assumed that the quality distribution of stringers is approximately the same when they are cut from raw material of similar quality.

Each part was "graded" into one of four grades developed from the pallet specifications of the National Wooden Pallet and Container Association, and used by the Forest Products Marketing Laboratory, United States Forest Service, in the conduct of the "PEP" study. The data obtained on the grade distribution of parts used in the "PEP" pallets is thus comparable to the data obtained from this study.

In general, the four grades were designed to allow the following distinctions:

Grade 2 & Better—approximately one-fourth reduction in strength due to defect.

Grade 3—approximately one-third reduction in strength due to defect.

Grade 4—approximately one-half reduction in strength due to defect.

Grade 5—cull—part with more than 50 percent reduction in strength due to defects.

The grading criteria are presented in detail in the appendix.

RESULTS

EASTERN HARDWOOD

Yields

Data were collected at mills from New York to Alabama to obtain a representative sample of species. Species mixes included maple, beech, and birch from the Northeast; oak from central Appalachia; and a mixture of oak and gum from the Southeast.

At seven different mills a total of 17,817 parts totaling 20,942 board feet were graded (table 1). At three of the seven mills, graded

4/4 lumber samples of approximately 1,000 board feet each of 2 Common, 3A Common, and 3B Common were cut into pallet parts. This provided information on the grade distribution of pallet parts cut from specific lumber grades. The lumber samples were selected in random lengths and widths from existing inventories at the pallet plants or supplier sawmills. The samples at the other four locations were of pallet grade and sound square edge material which was not sorted by standard lumber grades.

The results indicate that lumber grade and cutting method have a significant effect on the quality distribution of pallet parts. Species of wood did not affect the quality distribution of parts cut from lumber of comparable quality.

Hardwood pallet parts are produced normally by gang cutting, in which several saws cut simultaneously to produce several parts. For processing hardwood lumber into pallet parts a multiple crosscut process is employed to reduce a 10-foot board, for example, into three 40-inch deckboards. In this process, there is no opportunity to cut around defects. This is the process that was used to produce the "gang" cut parts evaluated in this study. Parts are also "gang" cut by cross-cutting cants to length and then processing the cants through a multiple-rip gang saw.

Selective cutting employs a single saw which makes one cut at a time to produce one part at a time. When this method is employed, the defects are usually cut out and several different lengths of parts may be produced from one board.

The gang method is the method most often used to produce hardwood pallet parts. Selective cutting is used mostly by manufacturers who lack the capital required to install gang saws. The selectively cut hardwood parts evaluated in this survey required an average cut-up time of 70 minutes per thousand board feet and yielded 85 percent usable volume. Gang-cut parts required an average cut-up time of only 31 minutes per thousand board feet and yielded 88 percent usable volume.

Gang-cut 3A Common lumber, the predominant grade used in hardwood pallets, yielded 42 percent Grade 2 and better parts, with 33, 16, and 9 percent in Grades 3, 4, and 5 respec-

Table 1.—Summary of eastern hardwood sample

Lumber grade	Total no. of parts graded	Total Volume (bd. ft.)	Predominant species
2 Common	2,023	2,741	Oak, Maple
3A Common	1,283	1,895	Oak, Maple
3B Common	1,697	2,599	Oak, Maple
Pallet grade (Northeast)	7,994	9,056	Maple, Oak, Beech
Pallet grade (Southeast)	4,820	4,651	Oak
Total	17,817	20,942	

Figure 1.—Quality distribution of hardwood pallet parts cut from three lumber grades by two cutting methods.

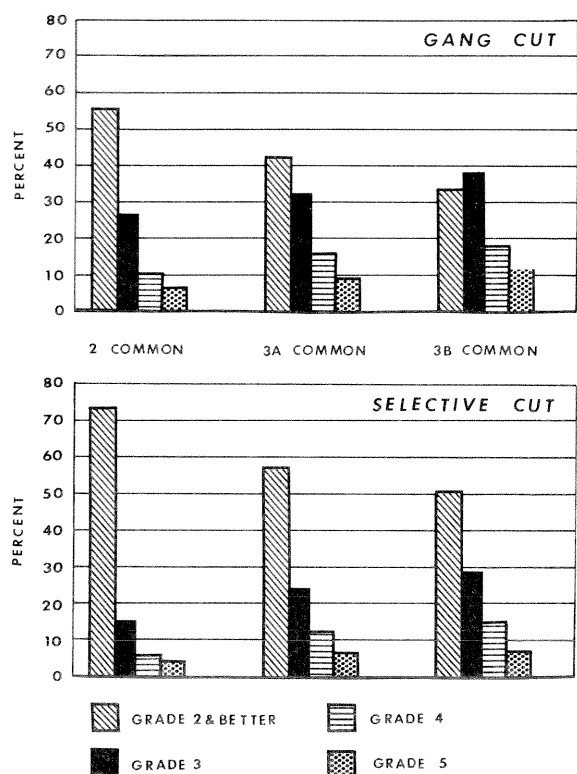


Figure 2.—Quality distribution of hardwood parts gang cut from pallet grade lumber in the North and South.

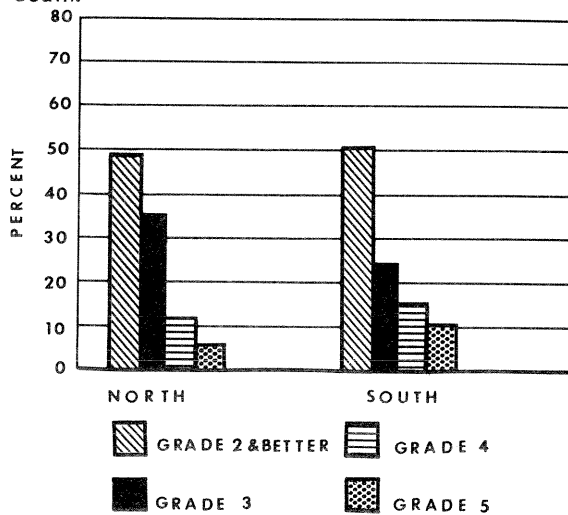
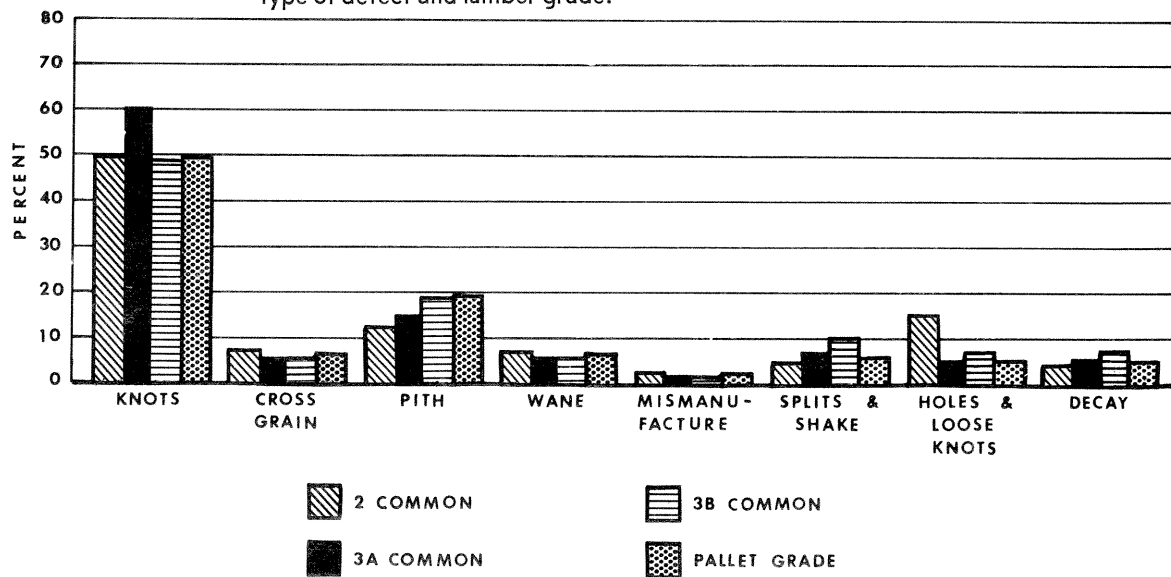


Figure 3.—Distribution of downgraded hardwood pallet parts by type of defect and lumber grade.



tively (fig. 1). Gang-cut No. 2 Common lumber yielded 56 percent Grade 2 and better parts, while 3B Common yielded 32 percent Grade 2 and better parts.

The three selectively cut samples of No. 2 Common, 3A Common, and 3B Common lumber yielded 74, 58, and 50 percent respectively Grade 2 and better parts.

The quality distribution of gang-cut parts from pallet grade lumber and cants closely resembled the distribution of gang-cut parts from 3A Common lumber (fig. 2). These similar distributions confirm the opinion of the pallet manufacturers that 3A Common grade comprises the major portion (approximately 60 percent) of the pallet grade category. Gang-cut pallet-grade lumber in the North yielded 48, 36, 11, and 5 percent in part Grades 2 and better, 3, 4, and 5 respectively. Gang-cut pallet-grade lumber in the South yielded 50, 25, 15, and 10 percent in part Grades 2 and better, 3, 4, and 5 respectively.

Defect Characteristics

The defects evaluated in the grading process consisted of knots, wane, pith, cross grain, splits and shake, holes and loose knots, decay, and mismanufacture. A defect severity scale relating these characteristics to the grades is included in the appendix.

Knots were the most frequent cause of downgraded parts (fig. 3). The percentage of parts downgraded because of knots ranged from 48 percent in parts cut from 3B Common to 61 percent in parts cut from 3A Common.

Pith was another major cause of downgrading, accounting for 19, 18, 15, and 12 percent of the defects in the parts cut from pallet grade, 3B Common, 3A Common, and 2 Common, respectively.

SOUTHERN PINE

Southern pine pallet parts were graded at two locations in the South. At one location the parts were cut from mill-run boards and dimension produced from small diameter logs. At the other location the parts were cut from No. 3 Grade dimension. Additional data on the quality distribution of parts cut from No. 2 Grade dimension is available from the PEP

Table 2.—Summary of southern pine sample

Lumber grade	Total no. of parts graded	Total volume (bd. ft.)
Mill-run	1,554	1,935
No. 3 Dimension	2,318	1,779
No. 2 Dimension	1,500	2,353
Total	5,372	6,067

research study report¹ and included here for comparative purposes (table 2).

The quality distribution of southern pine parts was similar to that of eastern hardwood (fig. 4). Number 2 Grade dimension yielded 62 percent Grade 2 and better parts while No. 3 Grade dimension yielded only 36 percent. The mill-run sample was intermediate, with 51 percent Grade 2 and better parts.

The distribution of downgraded parts by type of defect is shown in figure 5. Knots were by far the most frequent cause of downgrading, accounting for 90, 87, and 72 percent of the downgraded parts in the No. 2, mill-run, and No. 3 Grades respectively. The remaining defect categories were cross-grain, pith, and miscellaneous defects which included wane, splits and shake, holes and loose knots, and mismanufacture. The cross-grain, pith, and miscellaneous defects accounted for a relatively small percentage of the total number of downgraded parts.

DOUGLAS-FIR

Methods of producing pallet parts on the West Coast are radically different from those used in the Eastern United States.

A majority of the deckboards are cut from 8/4 Economy and Utility grade Douglas-fir and hemlock dimension. The 8/4 stock is resawn to produce lumber 11/16 to 3/4 inch thick. The lumber is then selectively cut into deckboards of the desired length.

Parts were graded at two locations on the West Coast. At one mill the resawn dimension was regraded and the resulting Construction Grade lumber was sold to the construction industry. The remaining lumber was processed into deckboards and sorted into two use classes—permanent and expendable. At the other location, all of the resawn dimension was proc-

Figure 4.—Quality distribution of southern pine pallet parts gang cut from three lumber grades.

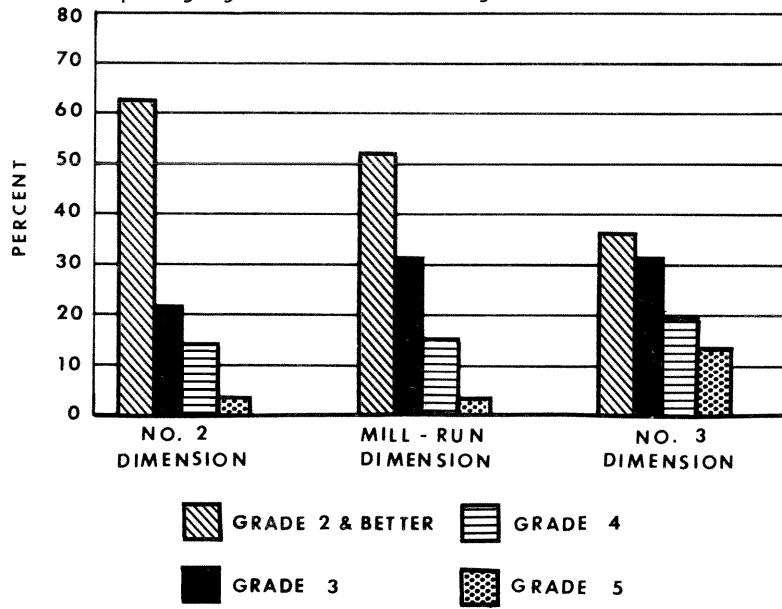
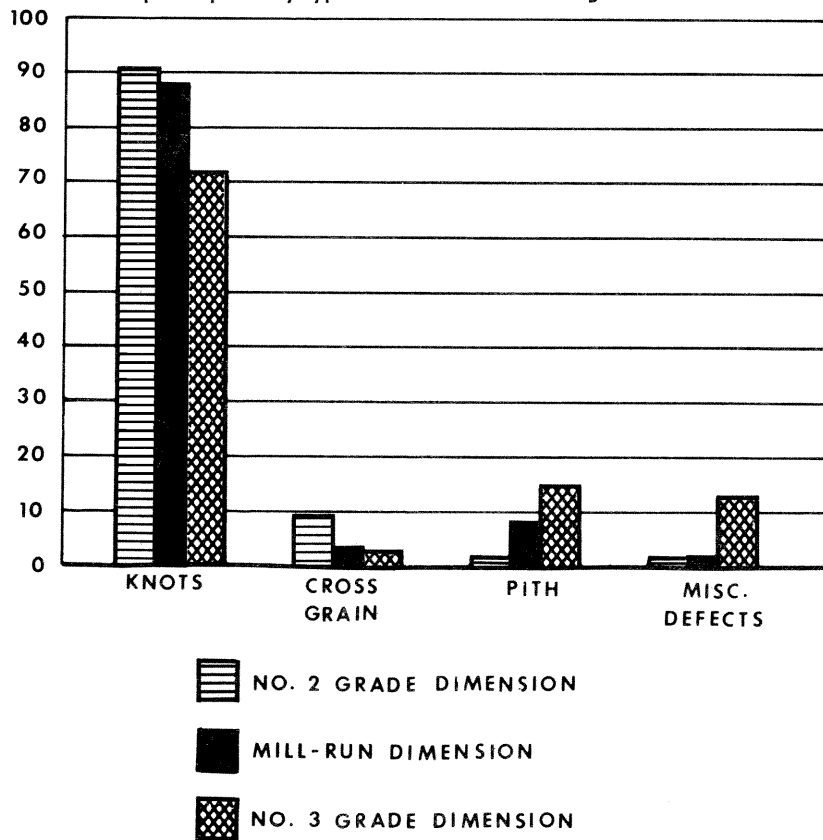


Figure 5.—Distribution of downgraded southern pine pallet parts by type of defect and lumber grade.



essed into deckboards and sorted into three use classes—clear, permanent, and expendable.

Clear quality parts are used in speciality products such as crates, bins, and boxes and do not normally go into warehouse pallets. Permanent quality parts are generally used in returnable or permanent pallets. The expendable parts are of very low quality, with knots, decay, and cross-grain the predominant types of defects. These parts are used exclusively in the assembly of nonreturnable, one-trip pallets. Because of this use classification, our grading efforts were concentrated on permanent quality parts.

Records collected over a 2-year period at one of the mills show that Economy grade dimension will yield 10, 30, and 30 percent in clear, permanent, and expendable quality parts, respectively, with 30 percent waste. The same records show that Utility grade dimension will yield 20, 60, and 10 percent in clear, permanent, and expendable quality, respectively, with 10 percent waste. Thus, only 40 percent of the Economy grade and 80 percent of the Utility grade dimension will yield parts suitable for permanent warehouse pallets.

The total sample consisted of 2,449 parts, a volume of 4,250 board feet (table 3).

The permanent quality component of both Economy and Utility grade lumber yielded 54 percent Grade 2 and better parts with 27, 10, and 9 percent in Grades 3, 4, and 5 respectively (fig. 6). The inclusion of the clear quality component (or the upgraded Construction grade lumber) in the total permanent mix would increase the amount of Grade 2 and better parts by 11 percent.

The distribution of downgraded parts by type of defect is shown in figure 7. Knots were the most frequent cause of downgrading, accounting for 56 percent of the downgraded permanent quality parts. Decay, cross grain,

Figure 6.—Grade distribution of "permanent" quality Douglas-fir pallet parts.

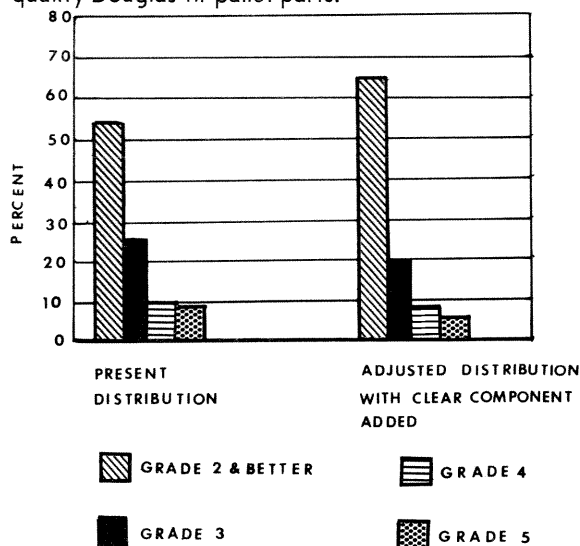


Figure 7.—Distribution of downgraded "permanent" quality pallet parts cut from Douglas-fir lumber.

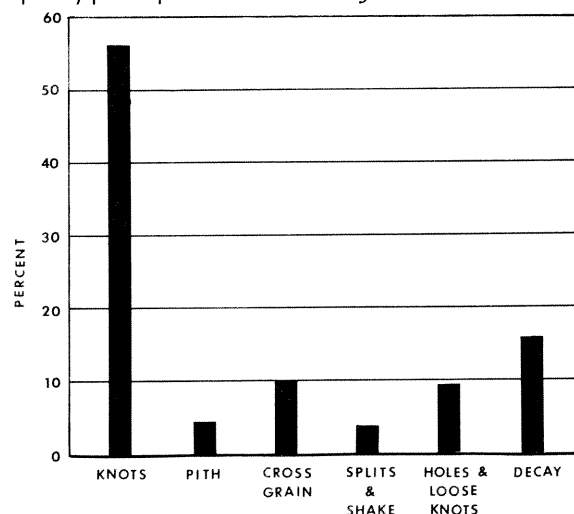


Table 3.—Summary of Douglas-fir sample

Lumber grade	Use class	Total no. of parts graded	Volume (bd. ft.)
Economy	Permanent	1,618	2,784
Utility	Permanent	831	1,466
Total		2,449	4,250

and holes were other major causes of downgrading, accounting for 16, 10, and 9 percent, respectively, of the defective parts.

Two hundred Douglas-fir and 100 hemlock 3- by 4- by 48-inch stringers were graded at one mill. The stringer stock had been manu-

factured and sorted in the normal production process of the mill. The grade composition of the Douglas-fir stringers was 42 percent Grade 2 and better, 19 percent Grade 3, 25 percent Grade 4, and 14 percent Grade 5. The hemlock had 63 percent Grade 2 and better, 12 percent Grade 3, 9 percent Grade 4, and 16 percent Grade 5 parts.

WESTERN HARDWOOD

A limited amount of tanoak lumber is used in pallet assembly on the West Coast. Tanoak is available in limited quantities and as a result has restricted commercial use. The

strength of tanoak is comparable to that of the more dense eastern hardwoods commonly used in pallet assembly. Because of its strength, tanoak could be used in small-order speciality pallets requiring hardwood, or to reinforce softwood pallets.

A small sample of tanoak parts was graded at one mill. The parts were selected at random from an experimental lot produced at a commercial sawmill to the same specifications as Douglas-fir stock. The parts were cut from Grade 3 and better lumber and comparable in quality to the parts cut from 2 Common eastern hardwood lumber. The quality distribution of the tanoak parts is shown in table 4.

Table 4.—Quality distribution of tanoak pallet parts

Parts	No. of pieces	Bd. ft.	Part distribution			
			Grade 2 & better	Grade 3	Grade 4	Grade 5
Stringers	150	400	67	Percent		
6-inch Deckboards	100	167	50	20	9	4
4-inch Deckboards	125	139	60	29	13	8
				20	16	4

CONCLUSIONS

This survey was conducted for the primary purpose of determining the quality distribution of pallet parts cut from low-grade eastern hardwood, southern pine, and Douglas-fir lumber and dimension now being used for permanent warehouse pallets. The following conclusions are indicated:

- There is sufficient amounts of high quality deckboards (Grade 2 and better) in existing pallet lumber mixtures to permit the placement of these parts in the vulnerable peripheral areas of the assembled pallet.

If the quality distribution of stringers is comparable to that of deckboards, the placement of Grade 2 and better stringers in outside positions (66 percent of the total

stringer volume) will require selective cutting, the use of higher grade lumber, lumber sorting, or some other method of improving the quality mix.

- There is a significant difference in the quality distribution of pallet parts cut from different grades of hardwood lumber.
- There is no appreciable difference in the quality distribution of pallet parts cut from different species of comparable quality.
- The cutting method employed has a significant effect on the quality distribution of the parts. The selective method yields a higher quality mix, and a lower output per man-hour.

APPENDIX

SUMMARY OF PALLET PART GRADING RULES

Wood characteristics such as pin knots, stain, small surface checks, mineral streaks, and pin worm holes that do not affect strength were not considered as defects.

(a) Knot size—The knot diameter relative to the width of the part determines the grade as follows:

- Knot diameter $\leq \frac{1}{4}$ part width — Grade 2 and Better
- Knot diameter $> \frac{1}{4}$ but $\leq \frac{1}{3}$ part width — Grade 3
- Knot diameter $> \frac{1}{3}$ but $\leq \frac{1}{2}$ part width — Grade 4
- Knot diameter $> \frac{1}{2}$ part width — Grade 5 (or Cull)

(b) Number of knots — Knots separated by more than 3 inches are considered as separate defects, otherwise the combined diameters of clusters of knots cannot exceed the limitations established in “a.”

- (c) Edge knots
 - (d) Knots in nailing area
 - (e) Knots above stringer notch
- } Reduce grade based on knot size by one grade.

(f) Splits, shake, and pitch streaks

- Sum of lengths $\leq \frac{1}{4}$ the length of the part — Grade 2 and Better
- Sum of lengths $> \frac{1}{4}$ but $\leq \frac{1}{2}$ the length of the part — Grade 3
- Sum of lengths $> \frac{1}{2}$ but $\leq \frac{3}{4}$ the length of the part — Grade 4
- Sum of lengths $> \frac{3}{4}$ the length of the part — Grade 5 (Cull)

(g) Cross grain

- Slope of grain $\leq 1:10$ — Grade 2 and Better
- Slope of grain $> 1:10$ but $\leq 1:8$ — Grade 3
- Slope of grain $> 1:8$ but $\leq 1:6$ — Grade 4
- Slope of grain $> 1:6$ — Grade 5

(h) Wane in deckboard or stringer — wane is measured in units of $1/256$ of the cross-sectional area.

- Wane ≤ 16 units — Grade 2 and Better
- Wane > 16 but ≤ 32 units — Grade 3
- Wane > 32 but ≤ 48 units — Grade 4
- Wane > 48 units — Grade 5

(i) Decay

- None allowed — Grade 2 and Better
- Occupying $\leq \frac{1}{8}$ cross-sectional area — Grade 3
- Occupying $> \frac{1}{8}$ but $\leq \frac{1}{4}$ cross-sectional area — Grade 4
- Occupying $> \frac{1}{4}$ cross-sectional area — Grade 5

(j) Knot holes and loose knots

- Hole diameter $\leq \frac{1}{8}$ the width of the part — Grade 2 and Better
- Hole diameter $> \frac{1}{8}$ but $\leq \frac{1}{6}$ the width of the part — Grade 3
- Hole diameter $> \frac{1}{6}$ but $\leq \frac{1}{4}$ the width of the part — Grade 4
- Hole diameter $> \frac{1}{4}$ the width of the part — Grade 5

(k) Mismanufacture

- Tolerance — Thickness $\pm \frac{1}{8}$ inch
- Width and length $\pm \frac{1}{4}$ inch
- Parts exceeding these limits are Grade 5 with no intermediate grade.

(l) Pith

- None allowed — Grade 2 and Better
- Face pith — Grade 3
- Boxed pith — Grade 4
- (No Grade 5 associated with pith).



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